

ERDC/EL SR-02-1

Environmental Laboratory



**US Army Corps  
of Engineers®**  
Engineer Research and  
Development Center

*Water Quality Research Program*

## **Watershed Modeling System Hydrological Simulation Program; Watershed Model User Documentation and Tutorial**

Patrick N. Deliman, Carlos E. Ruiz, Colby T. Manwaring,  
and E. James Nelson

July 2002

20020916 101

The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products.

The findings of this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.



PRINTED ON RECYCLED PAPER

# **Watershed Modeling System-Hydrological Simulation Program—FORTRAN; Watershed Model User Documentation and Tutorial**

by Patrick N. Deliman, Carlos E. Ruiz

Environmental Laboratory  
U.S. Army Engineer Research and Development Center  
3909 Halls Ferry Road  
Vicksburg, MS 39180-6199

Colby T. Manwaring, E. James Nelson

Brigham Young University  
P.O. Box 24009  
Provo, UT 84602-4009

Final report

Approved for public release; distribution is unlimited

# Contents

---

Preface .....	v
1—HSPF Interface .....	1
HSPF Model .....	1
HSPF Interface and WMS .....	1
Getting Started .....	2
Automated Segment Generation .....	4
Entering/Editing HSPF Attributes .....	5
Basin data .....	6
Reach/Reservoir data .....	7
Module Activity .....	7
Pervious land segment activity .....	7
Impervious land segment activity .....	8
Reach/Reservoir segment activity .....	8
HSPF Module Input .....	9
PWATER .....	10
SEDMNT .....	10
PQUAL .....	10
ATEMP .....	11
SNOW .....	11
MSTLAY .....	11
PEST .....	12
NITR .....	12
PHOS .....	12
TRACER .....	13
IWATER .....	13
SOLIDS .....	13
IQUAL .....	13
HYDR .....	14
ADCALC .....	14
CONS .....	14
HTRCH .....	15
SEDTRN .....	15
RQUAL .....	15
Mass Link Editor .....	17
WDM File Interaction .....	17
External sources .....	18
External targets .....	20

Viewing the HSPF output (WDM) data .....	20
Saving/Reading the HSPF Input File .....	22
Running HSPF .....	22
References and Bibliography .....	24
Appendix A: Watershed Modeling System, HSPF Tutorial.....	A1

SF 298

## List of Figures

---

Figure 1.	Watershed model in WMS .....	2
Figure 2.	HSPF Global Options dialog box .....	3
Figure 3.	Compute HSPF Land Segments .....	5
Figure 4.	Edit HSPF Attributes dialog box.....	6
Figure 5.	Pervious Land Activity dialog box.....	8
Figure 6.	Impervious Land Activity dialog box .....	8
Figure 7.	Reach/Reservoir Activity dialog box .....	9
Figure 8.	Mass Link Editor .....	18
Figure 9.	Assign External Sources dialog.....	19
Figure 10.	Assign External Targets dialog .....	21
Figure 11.	WDM datasets dialog box .....	22

# Preface

---

The work reported herein was conducted as part of the Water Quality Research Program (WQRP), Work Unit Number 32989. The WQRP is sponsored by Headquarters, U.S. Army Corps of Engineers (HQUSACE), and is assigned to the U.S. Army Engineer Research and Development Center (ERDC) under the purview of the Environmental Laboratory (EL), Vicksburg, MS. Funding was provided under Department of the Army Appropriation 96X3121, General Investigation. Dr. John W. Barko, ERDC, EL, was Program Manager for the WQRP, and Mr. Robert C. Gunkel, Jr., ERDC, EL, was Assistant Manager. Program Monitor during this study was Mr. James W. Wolcott, HQUSACE.

This report was prepared by Drs. Patrick N. Deliman and Carlos E. Ruiz, Water Quality and Contaminant Modeling Branch (WQCMB), Environmental Processes and Effects Division (EPED), EL, ERDC; and Messrs. Colby T. Manwaring and E. James Nelson, Brigham Young University, Provo, UT. Dr. Billy E. Johnson and Ms. Toni Toney, WQCMB, EPED, EL, were technical reviewers for this report.

The work was conducted under the general supervision of Dr. Richard E. Price, Chief, EPED, and Dr. Edwin Theriot, Director, EL, ERDC.

At the time of publication of this report, Dr. James R. Houston was Director of ERDC, and COL John W. Morris III, EN, was Commander and Executive Director.

This report should be cited as follows:

Deliman, P. N., Ruiz, C. E., Manwaring, C. T., and Nelson, E. J. (2002). "Watershed modeling system-Hydrological simulation program—FORTRAN; Watershed model User documentation and tutorial," ERDC/EL SR-02-1, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

*The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products.*

# 1 HSPF Interface

---

## HSPF Model

Hydrological Simulation Program—FORTRAN (HSPF) is an analytical tool designed to simulate hydrology and water quality in natural and man-made systems. HSPF is used to apply mathematical models to simulate the movement of water, sediment, and other constituents through watersheds. This analysis helps predict possible environmental problems in the watershed. With the growing need to care for and monitor the effects of man on the environment, it became apparent that a method for rapid analysis of those effects was needed.

The Watershed Modeling System (WMS) interface creates a way for the user to input a multitude of parameters into the input file and then to run HSPF. The input parameters are linked to all the tools within WMS, including automated basin delineation and parameter definition using a graphical user interface.

## HSPF Interface and WMS

As mentioned above, the purpose of including an interface to HSPF in WMS is to provide a way for engineers to delineate a watershed and set up an HSPF model quickly. The watershed delineation tools, as well as the Geographic Information System (GIS) tools, in WMS allow automated development of much of the input necessary for HSPF. However, several new tools and dialogs have been added to complete the HSPF input data.

Several custom dialogs and menu options have been developed in WMS to facilitate the definition of HSPF input data. Furthermore, HSPF can be launched directly from WMS through menu options. These menus can be found in the *Hydrologic Modeling Module* under the HSPF heading. Saving and reading HSPF input files (\*.uci) are also available in this menu.

Once a watershed has been delineated in WMS, several parameters that are used in HSPF can be calculated. Further, WMS provides tools to automatically divide basins in a watershed into land segments based on land-use data. This functionality will be discussed later in this chapter. Figure 1 shows how a watershed and the topographic tree appear in WMS for an HSPF simulation.

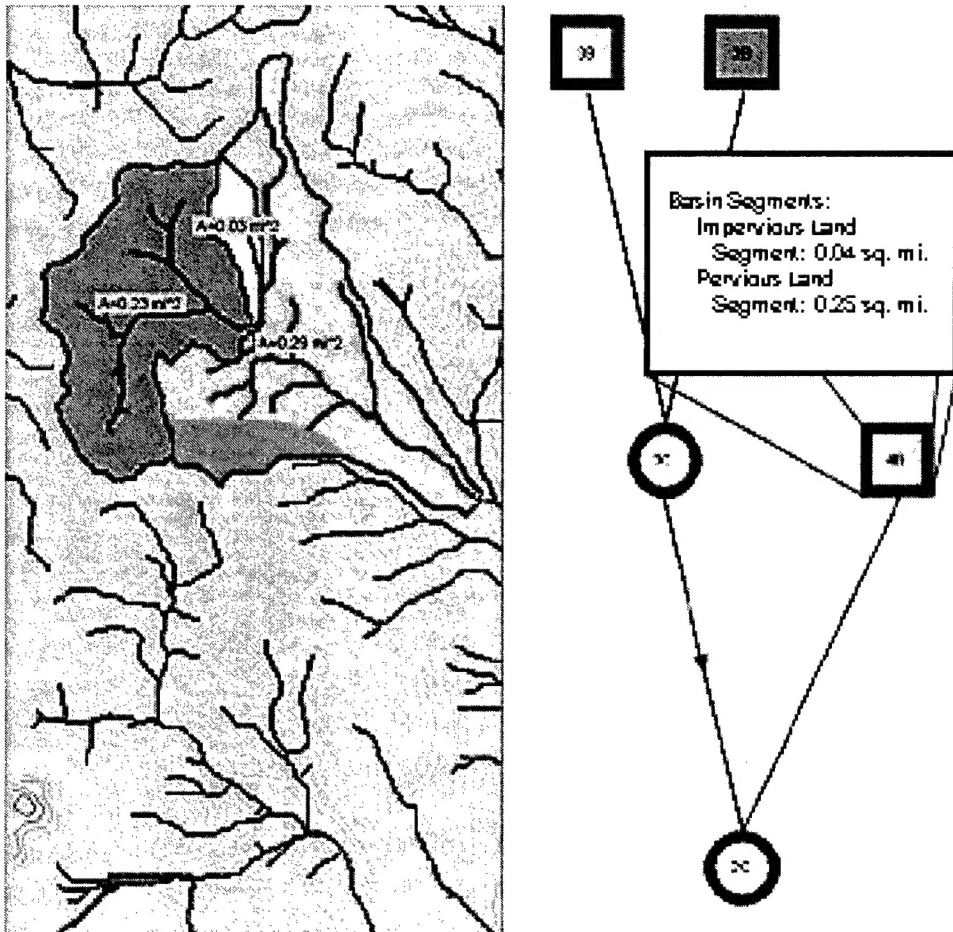


Figure 1. Watershed model in WMS

The dialogs in the HSPF interface in WMS allow the input of HSPF parameters for most user controlled input (UCI) file blocks and data tables commonly used in HSPF modeling. The input fields in each dialog have been defaulted to values recommended in the HSPF Manual (Bicknell et al. 1997).

## Getting Started

To begin an HSPF simulation in WMS, the HSPF data must be initialized for the watershed model. This is a simple procedure that involves the click of a button within the *HSPF Global Options* dialog box. Once the data are initialized, the user may access the various dialog boxes within the HSPF interface.

The following sections will describe the input dialogs involved in the interface and will explain the expected input parameters. It is recommended that the user consult the HSPF documentation to receive a complete description of how HSPF uses the parameters.

The *HSPF Global Options* dialog box is used to initialize the HSPF data for every hydrologic unit of the hydrologic tree and to set up parameters for the



overall simulation. This dialog is opened by selecting the *HSPF Global Options* command from the HSPF menu, as shown in Figure 2.

Figure 2. HSPF Global Options dialog box

The data for HSPF must be initialized before the user can access it; many features within the HSPF interface will be dimmed and remain dimmed until the user initializes the HSPF data. By clicking on the *Initialize HSPF Data* button within the *Global Options* dialog box, the user initializes all HSPF data within the watershed. The *Delete HSPF Data* button will remove all HSPF data from memory. This may be useful if the user wants to start over with HSPF input, or wants to use another model within WMS.

Once the HSPF data are initialized, several parameters are required in the *HSPF Global Options* dialog. Parameters required in the GLOBAL block of HSPF are input in this dialog. These include title, output levels, units flag, run flag, starting and ending times, and time step. Consult Section 4.1, HSPF Manual (Bicknell et al. 1997), for details on these parameters.

Also in this dialog are fields to define the input and output filenames of the HSPF run. Note that currently WMS only supports one WDM file and one output file per simulation. If more than one WDM file contains input for the simulation, these files should be merged for use with WMS. The filename fields complete the data necessary for the FILES block of HSPF (Section 4.2, HSPF Manual (Bicknell et al. 1997)). Each file name should have the appropriate extension attached in these fields. These file names may be set to the same prefix by entering the prefix in the designated field and clicking on the *Update Prefix* button.

## Automated Segment Generation

The core functionality of WMS allows the automated delineation of watershed and subbasins. Additional tools have been developed as part of the HSPF interface to allow automated breakdown of subbasins to land-use based segments. These segments can then be modeled as PERLND or IMPLND segments in HSPF. Once the HSPF simulation has been initialized, these tools can be accessed.

The division of subbasins to segments is performed as a GIS based combination of two data layers: a watershed data layer which contains basin boundary polygons and a land-use layer which contains land-use type polygons or gridded data. The two layers, or coverages, are compared to determine the land-use types which fall into each basin boundary. Then a segment is created for each land-use type in the basin. The area, type of segment (IMPLND or PERLND), and other parameters can be determined in this operation.

Automated segment generation in WMS is driven by the *Compute Composite...* dialog shown in Figure 3. Prior to invoking this dialog:

- a. A watershed must be delineated and basin data computed.
- b. A land-use coverage or grid must be read into WMS.
- c. HSPF data must be initialized in the *HSPF Global Options* dialog.

The dialog is opened by selecting the *Compute Composite...* option from the *Calculators* menu in the *Hydrologic Modeling* module.

To generate the HSPF segments:

- a. Select *HSPF Segments* from the *Computation Type* group.
- b. Make sure the units of the watershed and land-use data are set correctly by selecting the *Units* button and reviewing the settings.
- c. Check to ensure that the land-use coverage or grid is specified correctly.
- d. Import a table that relates land use to HSPF parameters. This table is a simple text file that lists land-use ID, description, and pervious attribute as shown below:

11, "RESIDENTIAL," "pervious"
12, "COMMERCIAL AND SERVICES," "impervious"
13, "INDUSTRIAL," "pervious"
16, "MXD URBAN OR BUILT UP," "impervious"
17, "OTHER URBAN OR BUILT UP," "pervious"
21, "CROPLAND AND PASTURE," "pervious"
32, "SHRUB & BRUSH RANGELAND," "pervious"

- e. Click OK.

**Compute Composite Runoff Coefficients/CN's**

**Computation**

☐ SCS Curve numbers  
☐ Rational method runoff coefficients  
☐ Green-Ampt parameters  
☒ HSPF segments

Use a [ ] for determining soil type.  
 Soil type/coverage name: [ ]

Use a [Land use coverage] for determining land use.  
 Land use coverage name: [land]

Drainage coverage computation step: [00.00000]

**Mapping**

☒ Land use mapping    ☐ Soil type mapping

ID	Perviousness	Land Use Description
11	pervious	RESIDENTIAL
12	pervious	COMMERCIAL AND SERVICES
13	pervious	INDUSTRIAL
16	pervious	MXD URBAN OR BUILT-UP
17	pervious	OTHER URBAN OR BUILT-UP

[Import]

[OK] [Cancel]

Figure 3. Compute HSPF Land Segments

This operation will create a segment for each unique land-use type in each basin, calculate the area, and assign the appropriate type (pervious or impervious) and name. These segments can then be modeled separately with HSPF. The following section will discuss how to edit attributes for each segment.

## Entering/Editing HSPF Attributes

Attributes or parameters for all land and reach segments of the topologic tree are viewed and/or edited using the *Edit HSPF Attributes* dialog (Figure 4). This dialog is accessed by selecting the *Edit HSPF Attributes...* command from the *HSPF* menu or by double clicking on a basin or an outlet when *HSPF* is the active model.



group is located in the basin area of the dialog box to allow the user to specify whether the segment is pervious or impervious. The *Define Activities...* button brings up dialog which allow the user to activate modules (i.e., PWAT, PQUAL, IWAT, etc.) for the selected segment and define the required parameters. The *External Targets...* button allows the user to define the output for the selected segment as required by the EXT TARGETS block of HSPF (Section 4.6.5, HSPF Manual (Bicknell et al. 1997)).

Below the text window listing the basin segments, buttons may be found to add or delete segments within the basin. The new basin segments default to pervious land segments with no specified area. This is a way to segment a basin manually if no land-use data exist to perform automatic segmentation.

### **Reach/Reservoir data**

The portion of the *Edit HSPF Attributes* dialog box that handles the input data for the RCHRES module of HSPF is located at the bottom of the *Edit HSPF Attributes* dialog box. Within that small section of the dialog box, the name of the RCHRES segment may be edited. The *Define Activities...* button located next to the edit field accesses a dialog used to activate the desired modules of RCHRES. The *External Targets...* button allows the user to define the output for the selected reach/reservoir as required by the EXT TARGETS block of HSPF (Section 4.6.5, HSPF Manual (Bicknell et al. 1997)).

## **Module Activity**

Each segment in an HSPF model may be set to model a variety of activities. Each segment type has different activities associated with it that may be turned on or off. The remainder of this section will describe the possible activities of each segment type.

### **Pervious land segment activity**

Clicking the *Define Activities...* button in the *Edit HSPF Attributes* dialog when a pervious segment is selected will open the *Pervious Land Activity* dialog. This dialog allows activation of the following modules: ATEMP, SNOW, PWATER, SEDMNT, PQUAL, MSTLAY, PEST, NITR, PHOS, TRACER. To activate a module, click the toggle box in the *Pervious Land Activity* dialog box, shown in Figure 5. This will activate the button that leads to the input dialog box for that module. Each of these modules will be explained in greater detail in later sections.

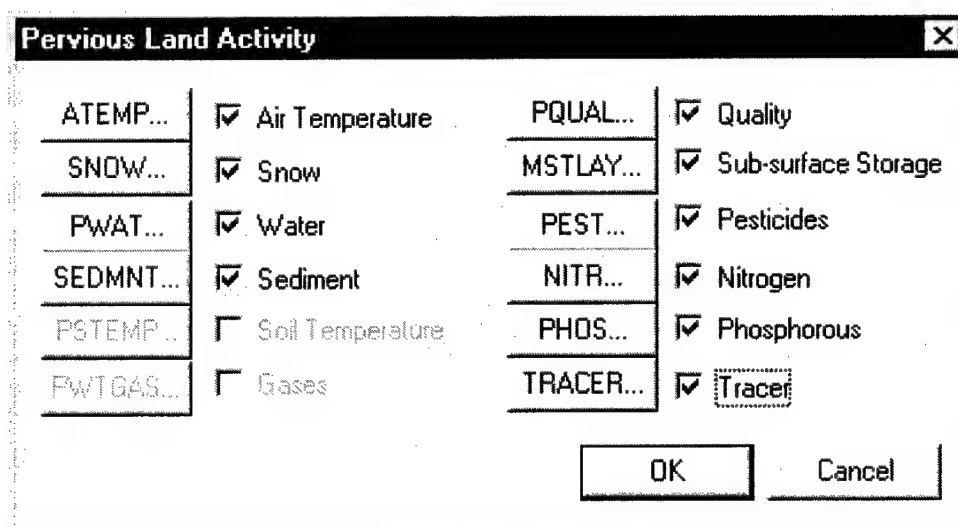


Figure 5. Pervious Land Activity dialog box

### Impervious land segment activity

Clicking the *Define Activities...* button in the *Edit HSPF Attributes* dialog when an impervious segment is selected will open the *Impervious Land Activity* dialog. This dialog allows activation of the following modules: ATEMP, SNOW, IWATER, SOLIDS, IQUAL. To activate a module, click the toggle box in the *Impervious Land Activity* dialog box, shown in Figure 6. This will activate the button that leads to the dialog box for that module. Each of these modules will be explained in greater detail in later sections.

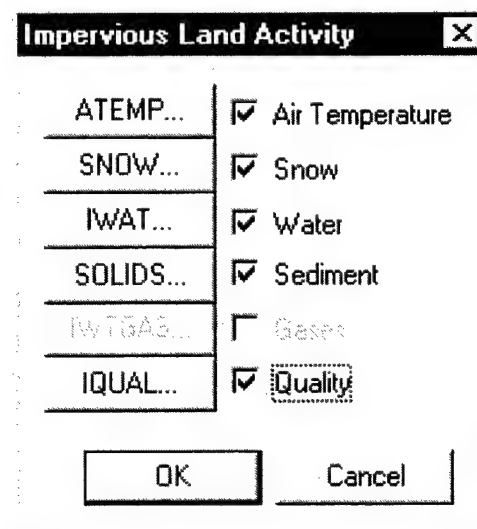


Figure 6. Impervious Land Activity dialog box

### Reach/Reservoir segment activity

The *Reach/Reservoir Activity* dialog allows activation of the following modules: HYDR, ADCALC, CONS, HTRCH, SEDTRN, RQUAL. To activate a module, click the toggle box in the *Reach/Reservoir Activity* dialog box, shown in Figure 7. This will activate the button that leads to the dialog box for that module. Each of these modules will be explained in greater detail in the following sections.

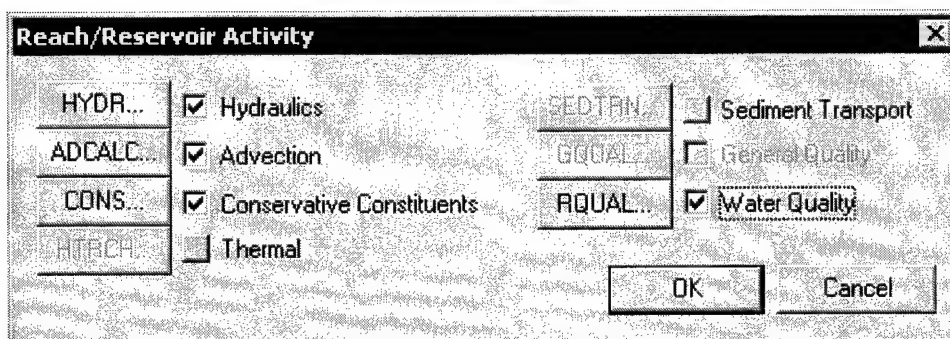


Figure 7. Reach/Reservoir Activity dialog box

## HSPF Module Input

Input for the modules in HSPF is handled in WMS by a dialog box created for each module. These dialog boxes share many common features and function in the same basic way. A brief description of the functionality of these dialogs will simplify the input of parameters to HSPF.

First, many parameters in HSPF may be input as a single value or monthly values, depending upon a flag that can be set in the module input. Such variables appear in the module dialogs with an edit field and a *Monthly Values...* button. Either the edit field or the button will be highlighted to indicate what input is expected. The expected input can be changed by finding the appropriate check or drop-down box in the flag section of the dialog and setting it on/off. Similarly, some data tables may be required or omitted depending upon flags set in the module input. The check boxes in the flags section of each dialog control the accessibility to fields and button for input to such tables. The correlation between flags and required input is covered in detail in the HSPF Manual (Bicknell et al. 1997) in the sections covering module input.

Next, in each dialog you will find a button entitled *External Sources...* leading to a dialog where the input time series for the selected land or reach/reservoir segment may be selected and assigned from a WDM file according to the EXT SOURCES block format (Section 4.6.2, HSPF Manual (Bicknell et al. 1997)). In a like manner, you will find an *External Targets...* button that leads to a dialog where output time series to be generated by HSPF can be assigned to WDM datasets (Section 4.6.5 – EXT-TARGETS block, HSPF Manual (Bicknell et al. 1997)). These dialogs will be discussed in detail later in this document.

Next, each dialog contains a button entitled *Apply Parameters to Segments...* that accesses the *Apply Parameters to Segments* dialog. The purpose of this dialog is to allow the user to select one or several segments to which module input parameters will be copied. This can greatly reduce the time and effort necessary to develop the input for an HSPF run. The layout and use of the *Apply Parameters to Segments* dialog is fairly simple. The window on the left side displays the names of all segments of a given type in the model. For example, if the dialog were brought up from the *IWATER Parameters* dialog, all of the impervious segments in the current model would be shown. The window on the right side of the *Apply Parameters to Segments* dialog lists the selected segments



to which parameters will be copied. Segments may be moved to and from the two windows by selecting the segment, then clicking the move arrows located between the windows. By moving segments to the *Selected Segments* window and clicking on *OK*, a list of those segments is stored so that when *OK* is clicked in the calling dialog (such as *IWATER Parameters*), parameters are copied from the selected segment to all segments in the list. Clicking *Cancel* in the calling dialog will delete the list.

Finally, the default parameter values for each module will appear in the input fields for all data tables in the module input dialogs, and help strings associated with each field give a reasonable range of values.

These items are common to all module input dialogs in WMS. Further discussion of each dialog follows in the next section, but the general topics covered should be sufficient to allow you to use any of the dialogs.

## **PWATER**

To access the *PWATER Parameters* dialog box, press the *PWATER* button in the *Pervious Land Activity* dialog box. The *PWATER Parameters* dialog box allows the user to enter the main parameters for the *PWATER* input tables: *PWAT-PARM1*, *PWAT-PARM2*, *PWAT-PARM3*, *PWAT-PARM4*, and *PWAT-STATE1*. The following monthly value tables may also be input from this dialog if required: *MON-INTERCEP*, *MON-UZSN*, *MON-MANNING*, *MON-INTERFLW*, *MON-IRC*, and *MON-LZETPARM*. Some parameters require a single value for the entire simulation and others are allowed to vary monthly, depending on the flags set in the *PWAT-PARM1* table. For information on the definition and function of specific variables in this module, refer to Section 4.4(1).4 – *PWATER* Input of the *HSPF Manual* (Bicknell et al. 1997).

## **SEDMNT**

To access the *SEDMNT Parameters* dialog box, press the *SED...* button in the *Pervious Land Activity* dialog box. The *SEDMNT Parameters* dialog box allows the user to enter the parameters for the *SEDMNT* input tables: *SED-PARM1*, *SED-PARM2*, *SED-PARM3*, and *SED-STOR*. The following monthly value tables may also be input from this dialog if required: *MON-COVER*, *MON-NVSI*. Some parameters require a single value for the entire simulation and others are allowed to vary monthly, depending on the flags set in the *SED-PARM1* table. For information on the definition and function of specific variables in this module, refer to Section 4.4(1).5 – *SEDMNT* Input, *HSPF Manual* (Bicknell et al. 1997).

## **PQUAL**

To access the *PQUAL Parameters* dialog box, press the *PQUAL...* button in the *Pervious Land Activity* dialog box. This dialog box allows the user to specify up to 10 water quality constituents or pollutants in the outflows from a pervious



land segment. The *PQUAL Parameters* dialog box allows the user to enter the parameters for the PQUAL input tables: NQUALS, PQL-AD-FLAGS, QUAL-PROPS, QUAL-INPUT. The following monthly value tables may also be input from this dialog if required: MON-POTFW, MON-POTFS, MON-ACCUM, MON-SQOLIM, MON-IFLW-CONC, and MON-GRND-CONC. Some parameters require a single value for the entire simulation and others are allowed to vary monthly, depending on the flags set in the QUAL-PROPS table. For more information on these tables, refer to Section 4.4(1).8 – PQUAL Input, HSPF Manual (Bicknell et al. 1997).

The key to using this dialog is to note that the *NQUAL* field at the top of the box designates the total number of constituents to be modeled, while the *Editing Constituent Number* drop-down box indicates the constituent that is available for editing in the fields below.

## **ATEMP**

To access the *ATEMP Parameters* dialog box, press the ATEMP... button in the *Pervious Land Activity* dialog box. The *ATEMP Parameters* dialog box allows the user to enter the parameters for the ATEMP input table: ATEMP-DAT. Note that the dialog for ATEMP input for PERLND and IMPLND segments is the same. For information on the definition and function of specific variables in this module, refer to Section 4.4(1).2 – ATEMP Input, HSPF Manual (Bicknell et al. 1997).

## **SNOW**

To access the *SNOW Parameters* dialog box, press the SNOW... button in the *Pervious Land Activity* dialog box. The *SNOW Parameters* dialog box allows the user to enter the parameters for the following SNOW input tables: ICE-FLAG, SNOW-PARM1, SNOW-PARM2, SNOW-INIT1, and SNOW-INIT2. Note that the dialog for SNOW input for PERLND and IMPLND segments is the same. For information on the definition and function of specific variables in this module, refer to Section 4.4(1).3 – SNOW Input, HSPF Manual (Bicknell et al. 1997).

## **MSTLAY**

To access the *MSTLAY Parameters* dialog box, press the MSTLAY... button in the *Pervious Land Activity* dialog box. The *MSTLAY Parameters* dialog box allows the user to enter the parameters for the following MSTLAY input tables: MST-PARM, MST-TOPSTOR, MST-TOPFLX, MST-SUBSTOR, and MST-SUBFLX. Note that fields for input to tables VUZFG, UZSN-LZSN, and MON-UZSN are also included in this dialog. These tables will be active and require input if MSTLAY is being modeled without PWATER active. For information on the definition and function of specific variables in this module, refer to Section 4.4(1).9 – MSTLAY Input, HSPF Manual (Bicknell et al. 1997).

## PEST

To access the *PEST Parameters* dialog box, press the PEST... button in the *Pervious Land Activity* dialog box. This dialog box allows the user to specify up to three pesticides on a pervious land segment. The *PEST Parameters* dialog box allows the user to enter the parameters for the PEST input tables: PEST-FLAGS, PEST-AD-FLAGS, SOIL-DATA, PEST-ID, PEST-THETA, PEST-FIRSTPM, PEST-CMAX, PEST-SVALPM, PEST-NONSVPM, PEST-DEGRAD, PEST-STOR1, and PEST-STOR2. The required combination of these tables varies, depending on the PEST-FLAG table values. For more information on these tables, refer to Section 4.4(1).10 – PEST Input, HSPF Manual (Bicknell et al. 1997).

The key to using this dialog is to note that the *NPST* field at the top of the box designates the total number of pesticides to be modeled, while the *Now Editing Pesticide* drop-down box indicates the constituent that is available for editing in the fields below.

## NITR

To access the *NITR Parameters* dialog box, press the NITR... button in the *Pervious Land Activity* dialog box. The *NITR Parameters* dialog box allows the user to enter the parameters for the NITR input tables: NIT-FLAGS, NIT-AD-FLAGS. In addition, buttons which lead to dialogs for input to the following tables are found in this dialog: NIT-FSTGEN, NIT-ORGPM, NIT-AMVOLAT, NIT-CMAX, NIT-SVALPM, NIT-UPTAKE, MON-NITUPT, SOIL-DATA2, CROP-DATES, NIT-YIELD, MON-NUPT-FR1, and MON-NUPT-FR2. The required combination of these tables varies, depending on the NIT-FLAG table values entered. In addition, a button that leads to the SOIL-DATA table dialog is active in this dialog if the PEST module is inactive. For information on the definition and function of specific variables in this module, refer to Section 4.4(1).11 – NITR Input, HSPF Manual (Bicknell et al. 1997).

## PHOS

To access the *PHOS Parameters* dialog box, press the PHOS... button in the *Pervious Land Activity* dialog box. The *PHOS Parameters* dialog box allows the user to enter the parameters for the PHOS input tables: PHOS-FLAGS, PHOS-AD-FLAGS, and PHOS-FSTGEN. In addition, buttons which lead to dialogs for input to the following tables are found in this dialog: PHOS-FSTPM, PHOS-CMAX, PHOS-SVALPM, PHOS-UPTAKE, MON-PHOSUPT, PHOS-YIELD, MON-PUPT-FR1, MON-PUPT-FR2, PHOS-STOR1, PHOS-STOR2. The required combination of these tables varies, depending on the PHOS-FLAG table values entered. In addition, a button that leads to the SOIL-DATA, SOIL-DATA2, and CROP-DATES tables dialog is active in this dialog if the PEST module and NITR module are inactive. For information on the definition and function of specific variables in this module, refer to Section 4.4(1).12 – PHOS Input, HSPF Manual (Bicknell et al. 1997).

## TRACER

To access the *TRACER Parameters* dialog box, press the TRACER... button in the *Pervious Land Activity* dialog box, explained previously. The *TRACER Parameters* dialog box allows the user to enter the parameters for the TRACER input tables: TRAC-ID, TRAC-AD-FLAGS, TRAC-TOPSTOR, and TRAC-SUBSTOR. For information on the definition and function of specific variables in this module, refer to Section 4.4(1).13 – TRACER Input, HSPF Manual (Bicknell et al. 1997).

## IWATER

To access the *IWATER Parameters* dialog box, press the IWATER... button in the *Impervious Land Activity* dialog box. The *IWATER Parameters* dialog box allows the user to enter the main parameters for the following IWATER input tables: IWAT-PARM1, IWAT-PARM2, IWAT-PARM3, and IWAT-STATE1. The following monthly value tables may also be input from this dialog if required: MON-RETN, MON-MANNING. Some parameters require a single value for the entire simulation and others are allowed to vary monthly, depending on the flags set in the IWAT-PARM1 table. For information on the definition and function of specific variables in this module, refer to Section 4.4(2).4 – IWATER Input, HSPF Manual (Bicknell et al. 1997).

## SOLIDS

To access the *SOLIDS Parameters* dialog box, press the SOLIDS... button in the *Impervious Land Activity* dialog box. The *SOLIDS Parameters* dialog box allows the user to enter the parameters for the following SOLIDS input tables: SLD-PARM1, SLD-PARM2, and SLD-STOR. The following monthly value tables may also be input from this dialog if required: MON-SACCUM, MON-REMOV. For information on the definition and function of specific variables in this module, refer to Section 4.4(2).5 – SOLIDS Input, HSPF Manual (Bicknell et al. 1997).

## IQUAL

To access the *IQUAL Parameters* dialog box, press the IQUAL... button in the *Impervious Land Activity* dialog box. This dialog box allows the user to specify up to 10 water quality constituents or pollutants in the outflows from an impervious land segment. The *IQUAL Parameters* dialog box allows the user to enter the parameters for the following IQUAL input tables: NQUALS, IQL-AD-FLAGS, QUAL-PROPS, QUAL-INPUT. The following monthly value tables may also be input from this dialog if required: MON-POTFW, MON-ACCUM, and MON-SQOLIM. Some parameters require a single value for the entire simulation and others are allowed to vary monthly, depending on the flags set in the QUAL-PROPS table. For more information on these tables, refer to Section 4.4(2).7 – IQUAL Input, HSPF Manual (Bicknell et al. 1997).

The key to using this dialog is to note that the *NQUAL* field at the top of the box designates the total number of constituents to be modeled, while the *Editing Constituent Number* drop-down box indicates the constituent that is available for editing in the fields below.

## HYDR

To access the *HYDR Parameters* dialog box, press the HYDR... button in the *Reach/Reservoir Activity* dialog box. The *HYDR Parameters* dialog box allows the user to enter the parameters for the following HYDR input tables: HYDR-PARM1, HYDR-PARM2, and HYDR-INIT. The following monthly value tables may also be input from this dialog if required: MON-CONVF. Other tables used to set up “categories” to be simulated are not supported in WMS. Some parameters require a single value for the entire simulation and others are allowed to vary monthly, depending on the flags set in the HYDR-PARM1 table. For information on the definition and function of specific variables in this module, refer to Section 4.4(3).2 – HYDR Input, HSPF Manual (Bicknell et al. 1997).

In addition to the fields and buttons to edit HYDR input variables, a few other buttons exist in this dialog. The *Print Info...* button leads to a dialog where the PRINT-INFO block for RCHRES segments may be set up (Section 4.4(3).1.2, HSPF Manual (Bicknell et al. 1997)). The *Define FTABLE...* button leads to a dialog where the FTABLE for the selected reach/reservoir may be input (refer to Section 4.5 – FTABLES Input, HSPF Manual (Bicknell et al. 1997)). This functionality will also be discussed later.

## ADCALC

To access the *ADCALC Parameters* dialog box, press the ADCALC... button in the *Reach/Reservoir Land Activity* dialog box. The *ADCALC Parameters* dialog box allows the user to enter the parameters for the ADCALC input table: ADCALC-DATA. For information on the definition and function of specific variables in this module, refer to Section 4.4(3).3 – SOLIDS Input, HSPF Manual (Bicknell et al. 1997).

## CONS

To access the *CONS Parameters* dialog box, press the CONS... button in the *Reach/Reservoir Activity* dialog box. This dialog box allows the user to specify up to 10 water quality constituents or pollutants in the flows from a reach/reservoir segment. The *CONS Parameters* dialog box allows the user to enter the parameters for the following CONS input tables: NCONS, CONS-AD-FLAGS, CONS-DATA. For more information on these tables, refer to Section 4.4(2).7 – IQUAL Input, HSPF Manual (Bicknell et al. 1997).

The key to using this dialog is to note that the *NCONS* field at the top of the box designates the total number of constituents to be modeled, while the *Currently Editing Constituent* drop-down box indicates the constituent that is available for editing in the fields below.

## HTRCH

To access the *HTRCH Parameters* dialog box, press the HTRCH... button in the *Reach/Reservoir Activity* dialog box. The *HTRCH Parameters* dialog box allows the user to enter the parameters for the following HTRCH input tables: HT-BED-FLAGS, HEAT-PARM1, HT-BED-DELH, HT-BED-DELTT, and HEAT-INIT. The following monthly value tables may also be input from this dialog if required: MON-HT-TGRND. Some parameters require a single value for the entire simulation and others are allowed to vary monthly, depending on the flags set in the HT-BED-FLAGS table. For more information on these tables, refer to Section 4.4(3).5 – HTRCH Input, HSPF Manual (Bicknell et al. 1997).

## SEDTRN

To access the *SEDTRN Parameters* dialog box, press the SEDTRN... button in the *Reach/Reservoir Activity* dialog box. The *SEDTRN Parameters* dialog box allows the user to enter the parameters for the following SEDTRN input tables: SANDFG, SED-GENPARM, SAND-PM, SILT-CLAY-PM, SSED-INIT, and BED-INIT. The SED-HYDPARM table may also be active if the HYDR module is inactive. The combination of required tables will vary, depending on the flags set in the SAND-FG table. The required tables will be listed in the drop-down list to indicate input that must be completed. Simply choose a table from the list, and the input fields for that table will appear. For information on the definition and function of specific variables in this module, refer to Section 4.4(3).6 – SEDTRN Input, HSPF Manual (Bicknell et al. 1997).

## RQUAL

This module is used to simulate the behavior of constituents involved in biochemical transformations. Unlike the other modules, this one has multiple sections that are each as involved as any other module. Those sections are OXRX, NUTRX, PLANK, and PHCARB, which model primary dissolved oxygen and biochemical oxygen demand balances, inorganic nitrogen and phosphorus balances, plankton populations and associated reactions, and pH and inorganic carbon species, respectively. The constituents that may be modeled using RQUAL are dissolved oxygen, biochemical oxygen demand, ammonia, nitrite, nitrate, orthophosphorus, phytoplankton, benthic algae, zooplankton, dead refractory organic nitrogen, dead refractory organic phosphorus, dead refractory organic carbon, pH, and carbon dioxide.

To access the *RQUAL Parameters* dialog box, press the RQUAL... button in the *Reach/Reservoir Activity* dialog box. The *RQUAL Parameters* dialog box allows the user to enter the parameters for the following RQUAL input tables:

BENTH-FLAG and SCOUR-PARMS. The four checkboxes and buttons located in the RQUAL dialog box lead to the four sections of the RQUAL module: OXRX, NUTRX, PLANK, and PHCARB. Input for those sections will be discussed in detail below. For information on the definition and function of specific variables in this module, refer to Section 4.4(3).8 – RQUAL Input, HSPF Manual (Bicknell et al. 1997).

**OXRX.** This section is used to simulate the primary processes that determine the dissolved oxygen concentration in a reach or mixed reservoir. To access the *OXRX Parameters* dialog box, press the OXRX... button in the *RQUAL Parameters* dialog box as explained previously. The *OXRX Parameters* dialog box allows the user to enter the parameters for the following OXRX input tables: OX-FLAGS, OX-GENPARM, ELEV, OX-BENPARM, OX-CFOREA, OX-TSIVOGLOU, OX-LEN-DELTH, OX-TCGINV, OX-REAPARM, and OX-INIT. A table may be edited by selecting it in the *Table Type* drop-down box; the required fields will then appear in the dialog.

The segment parameters for these tables are listed in the dialog box and the help strings include a range of values that are reasonable. The combination of required tables will vary, depending on the flags set in the OX-FLAGS table. For information on the definition and function of specific variables in this module, refer to Section 4.4(3).8.1 – OXRX Input, HSPF Manual (Bicknell et al. 1997).

**NUTRX.** This section of the RQUAL module simulates the primary processes which determine the balance of inorganic nitrogen and phosphorus in natural waters. This section is used to simulate the primary processes that determine the dissolved oxygen concentration in a reach or mixed reservoir. To access the *NUTRX Parameters* dialog box, press the NUTRX... button in the *RQUAL Parameters* dialog box. The *NUTRX Parameters* dialog box allows the user to enter the parameters for the following NUTRX input tables: NUT-FLAGS, NUT-AD-FLAGS, CONV-VALI, NUT-BENPARM, NUT-NITDENIT, NUT-NH3VOLAT, MON-PHVAL, NUT-BENCONC, NUT-ADSPARM, NUT-ADSINIT, and NUT-DINIT. A table may be edited by selecting it in the *Table Type* drop-down box; the required fields will then appear in the dialog.

The segment parameters for these tables are listed in the dialog box and the help strings include a range of values that are reasonable. The combination of required tables will vary, depending on the flags set in the NUT-FLAGS table. For information on the definition and function of specific variables in this module, refer to Section 4.4(3).8.2 – NUTRX Input, HSPF Manual (Bicknell et al. 1997).

**PLANK.** This section of the RQUAL module simulates phytoplankton, zooplankton, and/or benthic algae. To access the *PLANK Parameters* dialog box, press the PLANK... button in the *RQUAL Parameters* dialog box. The *PLANK Parameters* dialog box allows the user to enter the parameters for the following PLANK input tables: PLNK-FLAGS, PLK-AD-FLAGS, SUF-EXPOSED, PLNK-PARM1, PLNK-PARM2, PLNK-PARM3, PHYTO-PARM, ZOO-PARM1, ZOO-PARM2, BENAL-PARM, and PLNK-INIT. A table may be edited by selecting it in the *Table Type* drop-down box; the required fields will then appear in the dialog.

The segment parameters for these tables are listed in the dialog box, and the help strings include a range of values that are reasonable. The combination of required tables will vary, depending on the flags set in the PLNK-FLAGS table. For information on the definition and function of specific variables in this module, refer to Section 4.4(3).8.3 – PLANK Input, HSPF Manual (Bicknell et al. 1997).

**PHCARB.** This section of the RQUAL module simulates pH, carbon dioxide, total inorganic carbon, and alkalinity in the RCHRES. To access the *PHCARB Parameters* dialog box, press the PHCARB... button in the *RQUAL Parameters* dialog box. The *PHCARB Parameters* dialog box allows the user to enter the parameters for the following PHCARB input tables: PH-PARM1, PH-PARM2, and PH-INIT. A table may be edited by selecting it in the *Table Type* drop-down box; the required fields will then appear in the dialog. For information on the definition and function of specific variables in this module, refer to Section 4.4(3).8.4 – PHCARB Input, HSPF Manual (Bicknell et al. 1997).

## Mass Link Editor

The *Mass Link Editor* is a dialog box that is used to create links between two hydrologic units of the topologic tree and set up the MASS-LINK block of an HSPF run. Information on the MASS-LINK block may be found in Section 4.6.4.2, HSPF Manual (Bicknell et al. 1997). In WMS, a list of mass links may be created for each segment type: PERLND, IMPLND, and RCHRES. The mass links for each segment type will be applied to all segments of that type in the model.

The *Mass Link Editor* dialog (Figure 8) allows the user to add or delete mass links for each type of segment. To open the dialog, select *Mass Link Editor...* from the *HSPF* menu in the *Hydrologic Modeling* module. To add, just select the segment type from the box in the upper left of the dialog, select the appropriate options in the various combo boxes, input a value as the conversion factor, then hit the *Add Link* button. To delete, select the line in the text window to be deleted and click the *Delete Link* button.

If a number of mass links are to be used for many simulations, it would be wise to save the mass links to a file that would be read in any time they are needed. The *Export* button allows the user to specify a filename and then the mass links are saved as an UCI-formatted ASCII text file. The *Import* button allows the user to read in a previously saved mass link file.

## WDM File Interaction

HSPF requires several time series datasets as input for hydrologic modeling; it also reports results of simulation as time series datasets. These data are stored in a watershed data management (WDM) file. These files are binary, direct-access data files which can hold several thousand datasets. Thus, management of

Mass Link Editor

Segment type: PERLND Import File... Export File...

Volume	Group	Member	Factor	Target	Group	Member
PERLND	PWATER	PERS		RCHRES	INFLOW	IVOL

Add Link Delete Link

Volume

Name PERLND

Group PWATER

Member Name PERS

Multiplication Factor

1.00

Target

Name RCHRES

Group INFLOW

Member Name IVOL

OK Cancel

Figure 8. Mass Link Editor

the interaction with these WDM files is a large part of HSPF modeling. Datasets must be selected from the WDM file as input to a simulation and datasets must be specified as targets for simulation results. The EXT SOURCES and EXT TARGETS blocks of the HSPF input file control these interactions. Tools have been developed in WMS to aid in reviewing WDM files and setting up these input blocks for HSPF. The following sections will discuss these tools.

## External sources

Depending upon the options selected, HSPF requires input of a few or several time series. These time series are referred to as External Sources and should be located in a WDM file, which is specified in the *HSPF Global Options* dialog box. Not only must they exist in that file, but the time series must also be assigned to the proper segments according to the EXT SOURCES block of HSPF (Section 4.6.2, HSPF Manual (Bicknell et al. 1997)). The *Assign External Sources* dialog in WMS has been developed to allow the user to set up the required external sources for an HSPF run.



As mentioned various times above, a button labeled *External Sources...* is present in each of the HSPF (Figure 9) module dialogs in WMS. Upon clicking that button, the *Assign External Sources* dialog box is activated. In this dialog, the user may select time series from a WDM file and assign them to the selected segment.

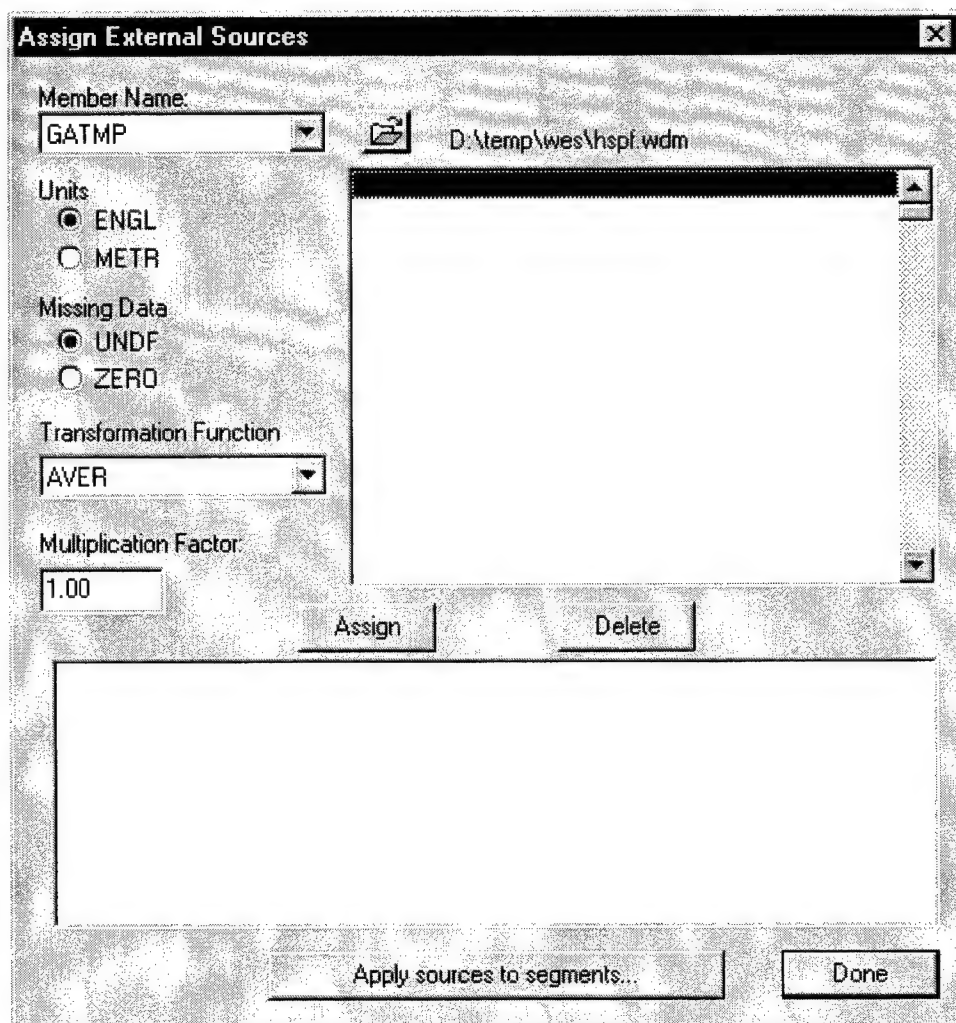


Figure 9. Assign External Sources dialog

To assign a time series, simply select it from the list on the right side of the dialog, select the target member name appropriate for that series, select the other options desired from the boxes on the left side of the dialog, then click the *Assign* button to add that source to the list that appears in the window at the bottom of the dialog. To delete a source, select it from the list in the bottom window and click the *Delete* button. Also included in this dialog is an *Apply sources to segments...* button. This button works in the same way the as the *Apply parameters to segments* button; the sources defined in the bottom window are copied to the chosen segments.

The sources specified for each segment of the HSPF model are written to the EXT SOURCES block of the UCI file when HSPF is run from WMS. For more information on the definition of external sources or the options available in this dialog, refer to Section 4.6.2 – EXT SOURCES block, HSPF Manual (Bicknell et al. 1997).

## External targets

The output from HSPF is also in the form of time series data. These time series are referred to as External Targets and will be written to a WDM file, which is specified in the *HSPF Global Options* dialog box each time HSPF is run. Thus, the user must specify what output is desired from HSPF and indicate where to write the output. The *Assign External Targets* dialog in WMS has been developed to allow the user to set up the desired external targets for an HSPF run. For more information on the options for external targets, refer to Section 4.6.5 – EXT-TARGETS block, HSPF Manual (Bicknell et al. 1997).

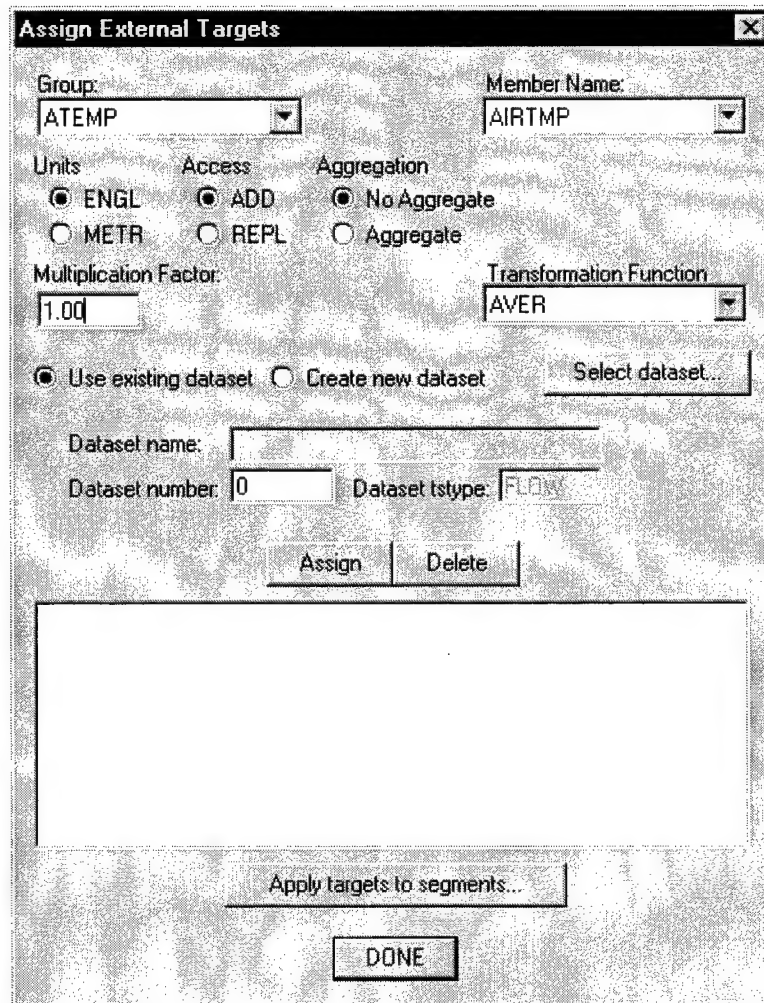
The *Assign External Targets* (Figure 10) dialog may be opened from the *Edit HSPF Attributes* dialog by clicking on the *External Targets* button in the *Basin Data* box or the *Reach/Reservoir Data* box. The targets setup will be assigned to the selected segment.

To assign a target, the following options must be set: the group to which the source time series belongs must be selected from the *Group* box; the source member name must be selected from the *Member Name* and subscript boxes; the units, access, aggregation, and transformation codes must be set; the multiplication factor should be entered; finally, the dataset to which to write the output data must be selected from the WDM file if the Use existing dataset option is chosen, or a dataset number, name, and tstype must be entered if Create new dataset is chosen. When the preceding options are set, clicking on the *Assign* button will add an external target to the list in the bottom window of the dialog. To delete a target, select it from the list in the bottom window and click the *Delete* button.

This dialog also contains an *Apply targets to segments...* button. This button works that same as the *Apply parameters to segments...* button explained previously; the targets defined will be copied to the selected segments.

## Viewing the HSPF output (WDM) data

As mentioned above, the output data from HSPF are stored in a WDM file. As in that file, the time series are used for input to HSPF. To view the datasets, open the *WDM Datasets* (Figure 11) dialog box by going to the *WDM Datasets...* command in the *HSPF* menu. The user should make sure the proper WDM file is listed at the top of the dialog; if not, the correct file may be chosen using the file browser. Once a file is chosen, the datasets present in the file will be listed by dataset number and name in the main window of this dialog.



**Assign External Targets**

Group:  Member Name:

Units: ☒ ENGL ☐ METR Access: ☒ ADD ☐ REPL Aggregation: ☒ No Aggregate ☐ Aggregate

Multiplication Factor:  Transformation Function:

☒ Use existing dataset ☐ Create new dataset

Dataset name:  Dataset number:  Dataset ttype:

Figure 10. Assign External Targets dialog

A dataset may be retrieved and plotted by doing the following:

- a. Select the dataset number/name from the main window.
- b. Note the starting date of the dataset; data will be retrieved from this time forward.
- c. Enter the number of values to be retrieved from the dataset.
- d. Selected the time units of the data.
- e. Select the transformation code used when retrieving the data.
- f. Click on the *Plot Dataset* button.

These steps will open the *Hydrograph Window* of WMS and plot the specified data as a linear plot. Some of the plot format may be changed by clicking on the *Plot Options...* button and setting the options as desired.

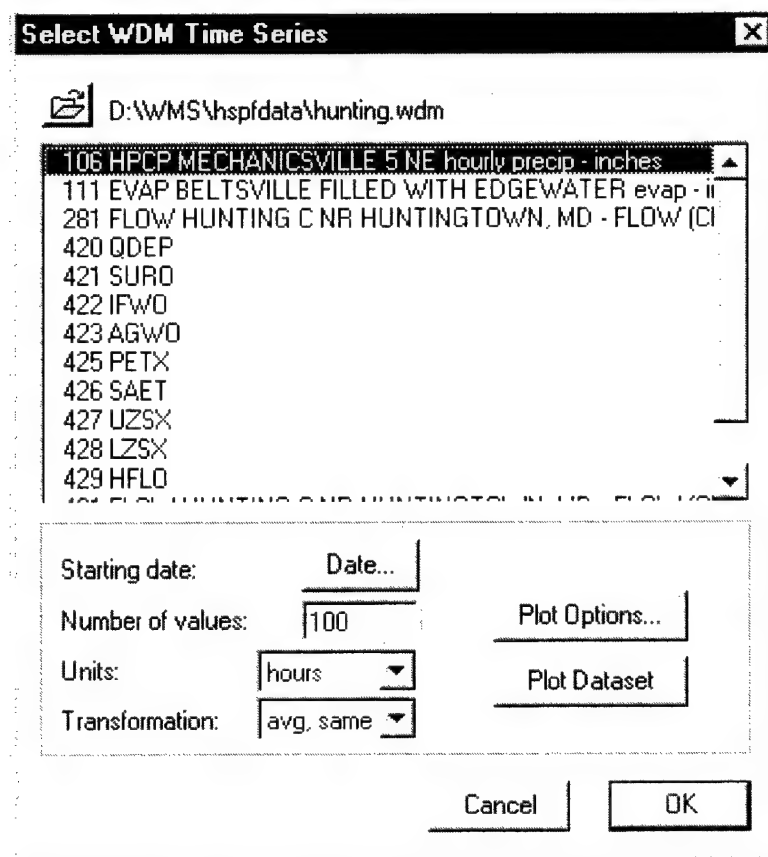


Figure 11. WDM datasets dialog box

## Saving/Reading the HSPF Input File

While working on the definition of HSPF parameter, or when finished, you will want to save the data in an HSPF input (\*.uci) file. The *Save HSPF File* item in the *HSPF* menu saves all HSPF input data to an HSPF input file (\*.uci). The format of this file is consistent with that defined in the HSPF users manual. This file may be named anything the user chooses but generally should have the *uci* extension. Note that the HSPF input file saves no geographic data; though the geographic data are not necessarily needed, it may be saved in a WMS superfile using the *Save As* command in the *File* menu.

Once an HSPF file has been saved, it may be read in later using the *Read HSPF File* command. Reading this file will build a topological tree and assign the HSPF parameters to the tree. Then the parameters may be edited as described previously.

## Running HSPF

Once the data for HSPF input have been defined, the HSPF model may be launched from WMS. The *Run HSPF* item in the *HSPF* menu will invoke the following dialog.

The *Run* HSPF dialog will allow the user to specify the input file, which is necessary to run *HSPF*. All other files required to run HSPF and to view the output were defined in the *HSPF Global Options* dialog box.

Once the input file has been defined and OK is selected, *HSPF* will be executed. A separate window will appear and information about the *HSPF* simulation will be reported. If you are running with Microsoft Windows, you must close this window when *HSPF* terminates.

If *HSPF* is not executed successfully when issuing this command, be sure that the path to the HSPF.EXE file is correct. If *HSPF* does not run to a successful completion you can view the ASCII output file using the *View File* command in the *File* menu to find the error messages.

## References and Bibliography

- Bicknell, B. R., Imhoff, J. C., Kittle, J. L., Donigian, A. S., Jr., and Johanson, R. C. (1997). "Hydrological Simulation Program – FORTRAN (HSPF): User's manual for Release 11," EPA/600/R-97/080, U.S. Environmental Protection Agency, Athens, GA.
- Donigian, A. S., Jr., and Duda, P. B. (1997). *LeSueur Watershed GenScn – A software system for evaluating watershed and water quality management scenarios in the LeSueur Basin of Southern Minnesota*. AQUA TERRA Consultants, Mountain View, CA, and Decatur, GA.
- Donigian, A. S., Jr., Bicknell, B. R., Linker, L. C., Hannawald, J. E., Chang, C., and Reynolds, R. (1990). "Chesapeake Bay Program – Watershed model application to calculate bay nutrient loading," Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Athens, GA.
- Donigian, A. S., Jr., Chinnaswamy, R. V., Beyerlein, D. C., and Carsel, R. F. (1993). "Surface water exposure assessment for Walnut Creek, Iowa." Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Athens, GA.
- Donigian, A. S., Jr., Imhoff, J. C., and Kittle, J. L., Jr. (1999). *HSPFParm, an interactive database of HSPF model parameters version 1.0*, AQUA TERRA Consultants, Mountain View, CA, Decatur, GA.
- Nelson, E. J. (1999). "Watershed modeling system reference manual," Environmental Modeling Research Laboratory, Provo, UT.
- U.S. Environmental Protection Agency. (1991). "Guidance for water-quality-based decisions: The TMDL process," EPA/440/4/91/001, Washington, DC.

# **Appendix A**

## **Watershed Modeling System**

### **WMS v6.1**

### **HSPF Tutorial**

---

#### **HSPF Interface**

This appendix demonstrates how the Watershed Modeling System (WMS) can be used to process digital elevation and land-use data to develop a Hydrological Simulation Program—FORTRAN (HSPF) user controlled input (.uci) file. The graphical user interface used to define input parameters is demonstrated for a basic hydrology simulation that includes doing the following:


- a.* Delineating watershed segment boundaries from a digital terrain model and U.S. Geological Survey (USGS) land-use file.
- b.* Defining segment parameters for a hydrologic analysis.
- c.* Developing reach segment parameters.
- d.* Defining precipitation time series data from standard .wdm database files.
- e.* Entering mass links to define transformations from basin to reach.

#### **Opening the Watershed and Initializing the HSPF Model**

You will open a watershed that has been delineated from a USGS 7.5' DEM and converted to a Triangular Irregular Network (TIN).

- a.* Select the *Open* command from the *File* menu.
- b.* Locate and choose the file named: *littlecotton.wpr*
- c.* Select *OK*.

The watershed will appear on your screen with the area displayed in the center of the basin. This indicates that the Basin Data has been computed and you are ready to set up the HSPF model. To initialize the model:

- a. Change to the *Hydrologic Modeling* module .
- b. Go to the *HSPF* menu and choose *HSPF Global Options*.
- c. Click the *Initialize HSPF Data* button – all fields will become active, indicating that the HSPF model is ready for input data.

You will now enter the parameters to indicate that the model will simulate about 3 years of time with a time step of 1 day. You will also name the model, choose the units to use, specify output levels, and name the input/output files:

- a. Enter Little Cottonwood Canyon Model in the Title field.
- b. Click on the *Start Time* button; enter *Year: 1996, Month: 1, Day: 1, Hour: 0, Minute: 0*.
- c. Click *OK*; the start date will appear to the right of the *Start Time* button.
- d. Click on the *End Time* button; enter *Year: 1999, Month: 7, Day: 31, Hour: 0, Minute: 0*.
- e. Click *OK*; the end date will appear to the right of the *End Time* button.
- f. Enter 24 in the *hours* field under the *Time step* heading (leave minutes at 0).
- g. Ensure that the *Units flag* is set to English.
- h. Change the *Run Flag* to 1; this indicates that HSPF will interpret the data and run the simulation (0 indicates that HSPF will only interpret – error check- the data).
- i. Set the *OUTLEV* to 10 (under *Output Levels*); this indicates maximum output to the Error and Warning files. Leave the *SPOUT* flag at 0 (this is only for Special Actions).
- j. In the *Files* section, enter *littlecotton* in the *Prefix* field, then click the *Update Filenames* button. This names all the HSPF input/output files associated with this model to the same name. **Note:** you have just indicated that you will be using a file named “littlecotton.wdm” for time series input and output – this file must be created and named appropriately outside of WMS (this has been done for you in this case).
- k. Select *OK*.

The Global Options are now set for the model. You are now ready to proceed to segmenting the watershed and entering parameters for the segments.



## Importing Land Use and Segmenting the Watershed

To divide this watershed into hydrologically similar segments, you will overlay a land-use data layer. You will read these data from an ArcView Shapefile:


- a. Go to the *File* menu and choose *Import*.
- b. Select the file named *littleclanduse.shp* and click *Open*.
- c. Click *OK* on the *Import File* dialog to indicate that you want to import a *Feature Object Polygon Shape File*.
- d. When the *Import Shapefile Data* dialog appears, click on the *Coverage Options* button. This will allow you to create a new coverage for the land-use data.
- e. Click *New* in the *Coverages* dialog, enter *Land-Use Data* in the *Name* field, and choose *Land Use* in the *Attribute Set* box.
- f. Click *OK* to return to the *Import Shapefile Data* dialog; note that the new coverage you just created is now active and listed by the *Coverage Options* button.
- g. Click on the *Attribute Mapping* button under *Polygons*. This will allow you to choose the database fields that correspond to WMS attributes.
- h. Choose *LUCODE* in the *Database fields* window and *Land Use* in the *Coverage attributes* window, then click on the *Map* button. You will see a new line appear in the lower window.
- i. Choose *PERIMETER=> Basin perimeter* line in the lower window and click *Unmap*. This attribute is recognized automatically by WMS, but is not needed in this case.
- j. Choose *Done*.
- k. Choose *OK* in the *Import Shapefile Data* dialog to read the file.

You will see the land-use data polygons overlaid on the watershed. You are now ready to compute HSPF segments based on the land-use polygons that fall inside the watershed.

- a. Go to the *Calculators* menu and choose *Compute GIS Attributes*.
- b. Choose *HSPF Segments* from the *Computation* drop-down list.
- c. In the central section of the dialog, ensure that *Land-use coverage* appears in the data type box and that *Land-Use Data* appears as the name of the coverage to be used for the computation.
- d. A text file that correlates the land-use ID to land-use attributes (name, perviousness, etc.) must be read in. Click the *Import* button to browse for this file.

- e. Choose the file named *littleclanduse.tbl*; Click *Open* to read it into WMS.
- f. Choose *OK* in the *Compute GIS Attributes* dialog to compute the HSPF segments.
- g. Click *OK* when warned that Continuing will delete all HSPF segment data.


You should now see the segments computed for the watershed displayed. Each colored area represents a segment to be modeled by HSPF. To better view the segments, you will need to change some display options.

- a. Switch to the *Map* module .
- b. Go to the *Feature Objects* menu and choose *Coverages*.
- c. Make sure that the *Land-Use Data* coverage is selected, then toggle OFF the *Visible* checkbox.
- d. Click *OK*; the land-use coverage is no longer visible.
- e. Go to the *Display* menu and choose *Display Options*.
- f. Choose the tab entitled *TIN*
- g. Toggle ON the *Land-use legend*.
- h. Click *OK*.

You should now see the land-use legend which shows the color and title of each segment in the watershed. You may want to Pan an/or Zoom to avoid having the legend appear over the watershed.



## Aggregating Segments

You will note from the display that there are several land segments in the watershed. Some are quite large, such as the Evergreen Forest Land segment, while others are rather insignificant, like Bare Exposed Rock. To make this simulation more simple, you will aggregate some of these segments and delete some others.

- a. Switch to the *Hydrologic Modeling* module .
- b. Select the basin icon by clicking on it.
- c. Go to the *HSPF* menu and choose *Edit HSPF Attributes*.
- d. Note in the *Edit HSPF Attributes* dialog the list of segments in the *Basin Data* window. There are eight separate segments (or land-use classifications) in this watershed.

There are two ways to reduce the number of segments computed by WMS. The first is to delete one segment, then add the area of the deleted segment to another similar segment (aggregate segments). The second is to delete the

segment, then let WMS redistribute the deleted area to the remaining segments (an area-weighted distribution is used).

- a. Choose segment entitled *Other Urban Or Build Up* from the *Basin Data* window. Note that the area is about 35 acres – insignificant in this watershed.
- b. Click the *Delete* Button.
- c. Repeat steps a and b for the segment entitled *Bare Ground*.
- d. Click *Done*.
- e. Switch to the *TIN* module .
- f. Go to the *Drainage* menu and Choose *Compute Basin Data*; click *OK* on the *Compute Basin Data* dialog to proceed. This will recompute basin data and distribute the areas of the deleted segments to the remaining segments.
- g. Now you will aggregate some segments. Switch back to the *Hydrologic Modeling* module .
- h. Select the basin icon by clicking on it.
- i. Go to the *HSPF* menu and choose *Edit HSPF Attributes*. Note that there are only six segments listed now.
- j. Choose the segment entitled *Mixed Forest*. Note the area of 445.775 acres; this is the area that you will add to the *Evergreen Forest* segment to aggregate the two segments.
- k. Click the *Delete* Button to delete segment 6.
- l. Choose *Evergreen Forest* segment. Note the area is 12,207.985 acres.
- m. Enter the new *Area* = 12,653.76 acres (12,207.985 + 445.775). You have successfully aggregated two segments.
- n. Aggregate segments by deleting the *Bare Exposed Rock* segment and adding its area to the segment *Mixed Tundra*. The new total area will be 1,385.752 acres.
- o. Choose *Done* to exit the *Edit HSPF Attributes* dialog.

You are now left with four land segments. These are the segments for which you will now input parameters and simulate with HSPF.

## Defining Land Segment Parameters

You are ready to begin defining parameters for the land segments of the HSPF model. This model will be set up for purely hydrologic analysis; thus, you will be activating and inputting parameters only to the SNOW and WATER modules of HSPF. Further, to decrease the time needed to complete the tutorial,

you will fully set up one segment and then copy those parameters to the other three segments in the model. Do the following to complete these tasks:

- a. Select the basin icon by clicking on it.
- b. Go to the *HSPF* menu and choose *Edit HSPF Attributes*.
- c. Choose the *Evergreen Forest* segment from the *Basin Data* window.
- d. Click the *Define Activities* button.
- e. Click the boxes next to *Snow (SNOW)* and *Water (PWAT)* to checkmark them. Note that the buttons become active upon checking the corresponding box.

You have just activated the Snow and Water modules for this pervious land segment. You must now enter the parameters for each active module to allow HSPF to simulate the segment correctly.

- a. Click on the *SNOW* button in the *Pervious Land Activity* dialog.
- b. In the *SNOW* dialog that appears, enter the following values in the appropriate fields (leave other fields at the default values; these values are either generally recommended values or HSPF defaults):

SNOW-PARM1	SNOW-PARM2	SNOW-INIT1	SNOW-INIT2
LAT = 40.5 degrees MELEV = 8410.8 ft SHADE = 0.40	TSNOW = 35.0 degrees MWATER = 0.2	Pack-snow = 4.0 in. Pack-ice = 2.0 in. Pack-watr = 2.0 in.	SKYCLR = 1.0
Note: These values were extracted from meteorological datasets.			

Now that all values are entered for this segment:

- a. Click the *Apply Parameters to Segments* button. This will allow you to assign these same parameters to other segments in the model.
- b. Choose *Shrub & Brush Rangeland* in the *Available Segments* window; move it to the *Selected Segments* window by clicking the → button.
- c. Repeat step b for *Residential* and *Mixed Tundra*.
- d. Click *OK*. The selected segments will be assigned the same parameters input here.

The final step in entering parameters for a module in HSPF is to define time series input (External Sources) and time series output (External Targets). For the land segments in this model, you will define External Sources for input data, but no External Targets will be specified – you will choose output to be given at the outlet of the watershed, not at each land segment.

- a. Click on the *External Sources* button in the *SNOW* dialog. The *Assign External Sources* dialog will appear with a list of the datasets available in the WDM file specified for this model (*littlecotton.wdm*).

- b. Assign the following datasets as sources by setting the fields to the appropriate values, then clicking the *Assign* button for each line. If you make a mistake, choose the incorrect line in the lower window and click *Delete*.

Member Name	Member Subscript	Units	Missing Data	Transformation	Quality Flag	Multiplication Factor	Dataset
PREC		ENGL	UNDF	SAME	0	0.25	3
PREC		ENGL	UNDF	SAME	0	0.75	7
DTMPG		ENGL	UNDF	AVER	0	1.0	14
WINMOV		ENGL	UNDF	AVER	0	1.0	15
SOLRAD		ENGL	UNDF	SAME	0	1.0	16
AIRTMP		ENGL	UNDF	AVER	0	0.4	17
AIRTMP		ENGL	UNDF	AVER	0	0.6	18

Since you will add other External Sources to this segment with the *PWAT* module input, you will not assign the External Sources to other segments yet.

- a. Click *Done* to return to the *SNOW* dialog.
- b. Click *OK* to return to the *Pervious Land Activities* dialog.

You have completed the setup of the *SNOW* module. You will now repeat the same basic steps to set up the *PWAT* module for the land segments of the model.

- a. Click on the *PWAT* button in the *Pervious Land Activity* dialog.
- b. In the *PWATER* dialog that appears, enter the following values in the appropriate fields (leave other fields at the default values):

PWAT-PARM1	PWAT-PARM2	PWAT-PARM3	PWAT-PARM4	PWAT-PARM5	PWAT-STATE1
CSNOFG = On RTOFG = On UZFG = On	LZSN = 5.0 INFILT = 0.48 LSUR = 2258.0 SLSUR = 0.25 KVARY = 0.7 AGWRC = 0.997	DEEPR = 0.1 PETMAX = 35.0 PETMIN = 30.0	CEPSC = 0.1 UZSN = 1.0 NSUR = 0.25 INTFW = 3.0 IRC = 0.7 LZETP = 0.8		CEPS = 0.2 UZS = 1.0 LZS = 6.0 AGWS = 1.6 GWWS = 1.9

Now that all values are entered for this segment:

- a. Click the *Apply Parameters to Segments* button. This will allow you to assign these same parameters to other segments in the model.
- b. Choose *Shrub & Brush Rangeland* in the *Available Segments* window; move it to the *Selected Segments* window by clicking the → button.
- c. Repeat step b for *Residential* and *Mixed Tundra*.
- d. Click *OK*. The selected segments will be assigned the same parameters input here.

Now you must define the additional External Sources needed for the *PWATER* simulation. Most of the External Sources entered for the *SNOW* module are also used for the *PWATER* module, but there is one input series is not yet entered.

- a. Click on the *External Sources* button in the *PWATER* dialog. The *Assign External Sources* dialog will appear with the sources that you created for this segment in the *SNOW* module listed in the lower window.
- b. Assign the following dataset (evapotranspiration) as a source by setting the fields to the appropriate values, then clicking the *Assign* button. If you make a mistake, choose the incorrect line in the lower window and click *Delete*.

Member Name	Member Subscript	Units	Missing Data	Transformation	Quality Flag	Multiplication Factor	Dataset
PETINP		ENGL	UNDF	SAME	0	1.0	23

All the External Sources needed for the simulation are now assigned to this segment. You will now copy these same External Sources to all other land segments in the model.

- a. Click the *Apply Sources to Segments* button. This will allow you to assign these same External Sources to other segments in the model.
- b. Choose *Shrub & Brush Rangeland* in the *Available Segments* window; move it to the *Selected Segments* window by clicking the → button.
- c. Repeat step *b* for *Residential* and *Mixed Tundra*.
- d. Click *OK*.
- e. Click *Done* in the *Assign External Sources* dialog.
- f. Click *OK* in the *PWATER* dialog.
- g. Click *OK* in the *Pervious Land Activity* dialog.

The *Edit HSPF Attributes* dialog should now be active. You have successfully set up the *SNOW* and *PWATER* modules for all land segments in the model (remember that you set up the modules explicitly for the Evergreen Forest segment and then copied the parameters to all other segments). You may want to ensure/review the setup for the other segments by choosing the segment in the *Basin Data* window, then clicking the *Define Activities* button, and reviewing the *SNOW* and *PWATER* input.

Now that the land segment data are complete, you will enter data for the reach (stream) segment of the model.

## Defining Reach Segment Parameters

To simulate runoff in-stream, you will need to activate the *HYDR* module for the reach segment of the model. You must specify the output dataset needed (a hydrograph in this case) to view the results of the simulation.

- a. Click on the watershed outlet in the *Graphics Window* (this can be done while the *Edit HSPF Attributes* dialog is still present; double-click the

outlet if you have already closed the *Edit HSPF Attributes* dialog). The *Reach/Reservoir Data* section of the *Edit HSPF Attributes* dialog will be come active and display the name of the outlet chosen (*Little*).

- b. Click on the *Define Activities* button.
- c. Check the box to activate the *Hydraulics (HYDR)* module of HSPF for this reach.
- d. Click the *HYDR* button in the *Reach/Reservoir Activities* dialog.
- e. In the *HYDR* dialog that appears, enter the following values in the appropriate fields (leave other fields at the default values):

HYDR-PARM1	HYDR-PARM2	HYDR-INIT
ODFVFG = 4	Length = 13.82 DeltaH = 2200.0	

The next input you must enter is the *FTABLE* for the reach. The *FTABLE* is a spreadsheet-like table that contains the conveyance parameters of the reach (depth, area, volume, and outflow). This table may be calculated manually or with the help of the *Channel Calculator* in WMS.

- a. Click on the *Define FTABLE* button the *HYDR* dialog.
- b. In the *FTABLE* dialog that appears, enter the following values (it is possible to change the number of rows and columns in the *FTABLE*, but the default values will be sufficient in this case):

Depth, ft	Area, ac	Volume, ac-ft	Outflow, cfs
0.0	0.0	0.0	0.0
0.25	25.99	6.393	13.876
0.5	26.828	12.995	43.954
0.75	27.666	19.807	86.269
1.0	25.50	26.828	139.241
1.25	29.340	34.059	201.950
1.5	30.181	41.499	273.794
1.75	31.019	49.150	354.355
2.0	31.858	57.009	443.334
2.25	35.211	90.540	879.902

Click *OK* to save the *FTABLE*.

The final task in defining the reach parameters is to specify the output you want to see from the reach and where HSPF will write the output. This is done by defining an *External Target*. You will specify that you want a hydrograph to be output to a dataset in the *WDM* (*littlecotton.wdm*) for this reach.

- a. Click on the *External Targets* button in the *HYDR* dialog.
- b. Set the following fields to the specified values:

Member Name	Member Subscript	Units	Access	Aggregation	Multiplication Factor	Quality flag	Transformation Function
RO		ENGL	REPL	Aggregate	1.0	0	AVER

Select the *Use Existing Dataset* button.

- Click on the *Select Dataset* button.
- In the *Select Dataset* dialog, scroll down and select dataset 20 (Flow), then click the *OK* button.
- The Dataset name, type, and number should appear in the *Assign External Targets* dialog.
- Click *Assign* to add the External Target line to the lower window.
- Click *Done*.

You have now completed the input for the HYDR module in this reach. This will be the only module active for this simulation; thus, you can exit the parameter editing dialogs.

- Click *OK* in the *HYDR* dialog.
- Click *OK* in the *Reach/Reservoir Activity* dialog.
- Click *Done* in the *Edit HSPF Attributes* dialog.

The input for all land and reach segments is now complete in the model. The last task before saving and running the HSPF model is to assign Mass Links.

## Creating Mass Links

Mass Links control how materials (water, sediment, constituents) are transferred from land segments to reaches, and from one reach to the next. Conversions in units, such as inches/acre per day of runoff → cubic feet per second, are defined in the Mass Links also. You will enter Mass Links to transfer water from land to reach and from reach to reach for this model.

- Go to the *HSPF* menu and choose *Mass Link Editor*.
- When you enter the *Mass Link Editor*, it is set to begin adding/deleting mass links for PERLND segments. Set the fields to the following values:

Volume Name	Volume Group	Volume Member Name	Multiplication Factor	Target Name	Target Group	Target Member Name
PERLND	PWATER	PERO	0.083333333	RCHRES	INFLOW	IVOL
Note: 0.0833333 is the conversion for inches/acre per day → cfs.						

- Click *Add Link* (if you make a mistake, select the link in the window and click the *Delete Link* button).
- Change the *Segment Type* (upper left) to IMPLND.
- Set the fields to the values below:

Volume Name	Volume Group	Volume Member Name	Multiplication Factor	Target Name	Target Group	Target Member Name
IMPLND	IWATER	SURO	0.083333333	RCHRES	INFLOW	IVOL



- a. Click Add Link.
- b. Change the *Segment Type* (upper left) to RCHRES.
- c. Set the fields to the values below:

Volume Name	Volume Group	Volume Member Name	Multiplication Factor	Target Name	Target Group	Target Member Name
RCHRES	HYDR	ROVOL	1.00	RCHRES	INFLOW	IVOL

After clicking *Add Link*, the Mass Links needed for PERLND, IMPLND, and RCHRES segments are now set up. You are ready to save and run the model.

Click *OK* to exit the *Mass Link Editor*.

## Saving and Running HSPF Simulation

The last step is to save and run the HSPF simulation. To do this, select the *Run HSPF* command from the HSPF menu. HSPF should run to completion. You will then be able to view the solution.

**REPORT DOCUMENTATION PAGE**Form Approved  
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. **PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.**

<b>1. REPORT DATE (DD-MM-YYYY)</b> July 2002		<b>2. REPORT TYPE</b> Final report		<b>3. DATES COVERED (From - To)</b>	
<b>4. TITLE AND SUBTITLE</b>  Watershed Modeling System Hydrological Simulation Program; Watershed Model User Documentation and Tutorial				<b>5a. CONTRACT NUMBER</b>	
				<b>5b. GRANT NUMBER</b>	
				<b>5c. PROGRAM ELEMENT NUMBER</b>	
<b>6. AUTHOR(S)</b>  Patrick N. Deliman, Carlos E. Ruiz, Colby R. Manwaring, E. James Nelson				<b>5d. PROJECT NUMBER</b>	
				<b>5e. TASK NUMBER</b>	
				<b>5f. WORK UNIT NUMBER</b>	
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b>  U.S. Army Engineer Research and Development Center Environmental Laboratory 3909 Halls Ferry Road Vicksburg, MS 39180-6199				<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b>  ERDC/EL SR-02-1	
<b>9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b>  U.S. Army Corps of Engineers Washington, DC 20314-1000				<b>10. SPONSOR/MONITOR'S ACRONYM(S)</b>	
				<b>11. SPONSOR/MONITOR'S REPORT NUMBER(S)</b>	
<b>12. DISTRIBUTION / AVAILABILITY STATEMENT</b>  Approved for public release; distribution is unlimited.					
<b>13. SUPPLEMENTARY NOTES</b>					
<b>14. ABSTRACT</b>  The Hydrological Simulation Program—FORTRAN (HSPF) is an analytical tool designed to simulate hydrology and water quality in natural and man-made systems. HSPF is used to apply mathematical models to simulate the movement of water, sediment, and other constituents through watersheds. This analysis helps predict possible environmental problems in the watershed. With the growing need to care for and monitor the effects of man on the environment, it became apparent that a method for rapid analysis of those effects was needed.  The Watershed Modeling System (WMS) interface creates a way for the user to input a multitude of parameters into the input file and then to run HSPF. The input parameters are linked to all the tools within WMS including automated basin delineation and parameter definition using a graphical user interface.  As mentioned above, the purpose of including an interface to HSPF in WMS is to provide a way for engineers to delineate a watershed and set up an HSPF model quickly. The watershed delineation tools, as well as the Geological Information System tools, in WMS allow automated development of much of the input necessary for HSPF. However, several new tools and dialogs have been added to complete the HSPF input data.  (Continued)					
<b>15. SUBJECT TERMS</b> Hydrological Simulation Program— FORTRAN (HSPF)      Water quality-Mathematical models      Watershed Modeling System (WMS)					
<b>16. SECURITY CLASSIFICATION OF:</b>			<b>17. LIMITATION OF ABSTRACT</b>	<b>18. NUMBER OF PAGES</b>  41	<b>19a. NAME OF RESPONSIBLE PERSON</b>
<b>a. REPORT</b>  UNCLASSIFIED	<b>b. ABSTRACT</b>  UNCLASSIFIED	<b>c. THIS PAGE</b>  UNCLASSIFIED			<b>19b. TELEPHONE NUMBER (include area code)</b>

#### **14. (Concluded)**

To begin an HSPF simulation in WMS, the HSPF data must be initialized for the watershed model. This is a simple procedure that involves the click of a button within the *HSPF Global Options* dialog box. Once the data are initialized, the user may access the various dialog boxes within the HSPF interface.

The following sections will describe the input dialogs involved in the interface and will explain the expected input parameters. It is recommended that the user consult the HSPF documentation to receive a complete description of how HSPF uses the parameters.